SILENT CHAIN

Field of the Invention

The present invention pertains to a silent chain; more specifically, to a silent chain that reduces abrasion of the guiding surface of a chain guide used with the silent chain.

Background of the Invention

A silent chain may be used as a power transmission chain or a timing chain for an automobile or a motorcycle. As illustrated in Figures 5 and 6, for example, a silent chain 1' may have a configuration in which many link plates 2' each having a pair of tooth parts 21' and pin holes 22' are stacked in the thickness direction as well as in the length direction, and respective link plates 2' are linked together using linking pins 3' inserted into respective pin holes 22'. Guide links 4' can be provided on the outermost sides of link plates 2', and the ends of linking pins 3' can be fixed in pin holes 41' of guide links 4'. Furthermore, here, a case is exemplified in which a so-called low rigidity guide link, which has a crotch part created on its rear side, can be utilized for the guide link.

In this kind of silent chain, as illustrated in Figure 7a, the link hole diameter of link plate 2' can be denoted as $\phi Dl'$, and the pin diameter of linking pin 3' as ϕd, establishing a relationship that may be expressed as $\phi Dl' > \phi d$. In addition, as illustrated in Figure 7b, the pin hole diameter of guide link 4' can be denoted as $\phi Dg'$, establishing a relationship that can be expressed as $\phi Dg' < \phi d$.

In other words, link plate 2' and linking pin 3' may be fitted with a clearance, whereby respective link plates 2' can rotate around linking pins 3' in order to

allow the entire chain to bend. Conversely, guide link 4' and linking pin 3' may be fitted tightly, and respective guide links 4' are press-fit to linking pins 3', whereby, linking pins 3' can be prevented from falling out.

In addition, the distance from pin hole centerline Ll' of link plate 2' to rear surface or chain guide contact surface 23' can be denoted as hl', and the distance from pin hole centerline Lg' of guide link 4' to rear surface or chain guide contact surface 43' of guide link 4' can be denoted as hg', establishing a relationship that may be expressed as hl' = hg'.

As illustrated in Figure 8, when the silent chain with such a configuration is driven, wear 52 may result due to abrasion of guiding surface 51 of chain guide 5.

The following mechanism may be considered to account for this wear. When a conventional silent chain makes contact with the chain guide, clearance c (= ϕDl' - ϕd) may be created between pin holes 22' of respective link plates 2' and linking pins 3', as illustrated in Figure 9. Accordingly, clearance e' (= c/2) may be created between guiding surface 51 of chain guide 5 and the rear surface 23' of respective link plates 2'.

When a conventional silent chain runs on guiding surface 51 of chain guide 5 under such conditions, if only guide links 4' make contact with guiding surface 51, the pressure of the contact surface against the guiding surface 51 may increase. As a result, edge-like abrasive wear 52 may be created on guiding surface 51 after the chain is driven for some time, if only guide links 4' make contact with the guiding surface 51.

Another configuration of a silent chain may comprise a rear wheel-driving silent chain, such as used as power transmission chains or timing drive chains for automobiles and motorcycles, is illustrated in Figures 12 and 13, where like reference numerals with the above-

described conventional silent chain generally indicate similar elements in the conventional rear wheel-driving silent chain. For example, rear wheel-driving silent chain 1' may comprise a plurality of link plates 2', each having a pair of pinholes 21' and a pair of teeth 22' on either side of the center line of the pinholes, stacked in the thickness direction as well as in the length direction. Respective link plates 2' may be linked together using linking pins 3' inserted into respective pinholes 21'. Guide links 4' can be provided on the outermost sides of link plates 2', and ends of linking pins 3' can be fixed in pinholes 41' of guide links 4'.

In this kind of rear wheel-driving silent chain, as illustrated in Figure 14a, the link hole diameter of link plate 2' can be denoted as $\phi Dl'$, and the pin diameter of linking pin 3' can be denoted as ϕd, establishing a relationship which may be expressed as $\phi Dl' > \phi d$. In addition, as illustrated in Figure 14b, the pin diameter of guide link 4' can denoted as $\phi Dg'$, establishing a relationship which may be expressed as $\phi Dg' < \phi d$.

In other words, link plate 2' and linking pin 3' are formed with a clearance; whereby, respective link plates 2' rotate around linking pins 3' in order to allow the entire chain to bend. In contrast, guide link 4' and linking pin 3' may be fit together tightly, and respective guide links 4' may be press-fit to linking pins 3'; whereby, linking pins 3' can be prevented from falling out.

In addition, the distance from pinhole center line Ll' of link plate 2' to chain guide contact face 23' is denoted as hl', and the distance from pinhole center line Lg' of guide link 4' to chain guide contact face 43' of guide link 4' can be denoted as hg', establishing a relationship which may be expressed as $hl' = hg'$. Furthermore, in this case, chain guide contact faces 23' and 43' are provided respectively on either side of pinhole

center lines Ll' and Lg' of link plate 2' and guide link 4'.

As illustrated in Figure 15, when this kind of conventional rear wheel-driving silent chain contacts the chain guide, clearance c (= ϕDl' - ϕd) is created between pinholes 21' of respective link plates 2' and linking pins 3'. Accordingly, clearance e' (= c/2) is created between guiding face 51 of chain guide 5 and chain guide contact face 23' of respective link plates 2'.

It is conceivable to eliminate such clearance e' in order for chain guide contact face 23' of link plate 2' to contact guiding face 51 of chain guide 5. However, chain guide contact face 23' is provided at the tip of triangular tooth 22', so that the area in contact with guiding face 51 is small. Thus, when chain guide contact face 23' contacts guiding face 51, the contact face pressure on chain guide contact face 23' increases, and abrasion of chain guide contact face 23' and guiding face 51 can be assumed to take place. In contrast, chain guide contact face 43' of guide link 4' is a flat surface, so that the area in contact with guiding face 51 is large.

Summary of the Invention

The present invention is directed to a silent chain which reduces abrasion of the guiding surface of a chain guide. According to an aspect of the invention, guide links and link plates may be arranged such that the guide links substantially contact the chain guide. According to another aspect of the invention, guide links and link plates may be arranged such that the link plates substantially contact the chain guide.

According to an aspect of the invention, a silent chain in which many link plates each having a pair of tooth parts and pin holes are stacked in the thickness direction as well as in the length direction and are linked together

using linking pins, guide links are provided on the outermost sides, and the guide links are fixed to the ends of the linking pins, when the distance from the pin hole centerline of the link plate to the surface facing chain guide can be denoted as hl, and the distance from the pin hole centerline of the guide link to the surface facing the chain guide can be denoted as hg, a relationship that can be expressed as hl > hg may be established.

Therefore, the chain guide contact surface of the link plate can be brought closer to the guiding surface than in a conventional chain, and contact may be made with the chain guide. Accordingly, intensive contact between the guide links alone and the guiding surface of the chain guide can be limited. As a result, abrasion of the guiding surface of the chain guide can be reduced.

In an aspect of the silent chain of the invention, the clearance between the pin hole of the link plate and the linking pin can be denoted as c, and a relationship that can be expressed as $hl \geq hg + c/2$ may be established.

In such a case, when contact is made with the chain guide, the chain guide contact surface of the link plate can be reliably brought into contact with the guiding surface of the chain guide. Accordingly, contact surface pressure against the guiding surface can be reduced, so that abrasion of the guiding surface can be further reduced.

In another aspect of the silent chain of the invention, the guide link may comprise a low rigidity guide link in which a crotch part can be created in the surface facing the chain guide or the rear side.

In yet another aspect of the silent chain of the invention, the plate link may comprise a rear-driven link plate having a pair of tooth parts on either side of the pin hole centerline.

In another aspect of the silent chain of the invention, the surfaces at the shoulder parts of the guide link on the chain guide side do not protrude beyond the shoulder parts of the link plate on the chain guide side while in contact with the guiding surface of the chain guide.

Accordingly, contact is made with the guiding surface of the chain guide, the surfaces at the shoulder parts of the guide link on the chain guide side can be prevented from coming into contact with the guiding surface. As a result, uneven abrasion of the guiding surface of the chain guide caused by the shoulder parts of the guide link making contact can be prevented.

According to another aspect of the invention, a rear wheel-driving silent chain may comprise a plurality of link plates, each having a pair of pinholes and a pair of teeth on either side of the center line of the pinholes, stacked in the thickness direction as well as in the length direction and linked together using linking pins, and guide links on the outermost sides, where the guide links can be fixed to the ends of the aforementioned linking pins by means of press-fitting. If the distance from the pinhole center line of the aforementioned link plate to the surface facing the chain guide is denoted as hl, and if the distance from the pinhole center line of the aforementioned guide link to the surface facing the chain guide is denoted as hg, the relationship hg > hl is established.

Because the aforementioned relationship is established, the clearance between the chain guide contact face of the link plate and the guiding face of the chain guide may be greater than c/2 (c: clearance between the pinhole of the link plate and the linking pin) while in contact with the chain guide when compared with a conventional chain. Thus, only the chain guide contact face of the guide link contacts the guiding face of the

chain guide over a long driving time. As a result, the contact face pressure of the chain guide acting on the guiding face can be reduced, so that abrasion of the guiding face can be reduced.

In contrast, for the case of the conventional rear wheel-driving silent chain, the clearance between the chain guide contact face of the link plate and the guiding face of the chain guide may be merely c/2 while in contact with the chain guide. If the total amount of abrasion of the chain guide contact face of the guide link and the guiding face of the chain guide exceeds c/2, the chain guide contact face of the link plate may contact the guiding face of the chain guide, so that the contact pressure on the guiding face increases, and wear may be generated on the guiding face.

In another aspect of a silent chain according to an aspect of the invention, the clearance between the pinhole of the aforementioned link plate and the aforementioned linking pin may be denoted as c, establishing a relationship which may be expressed as $hg \geq hl + c/2$.

In this case, the clearance between the chain guide contact face of the link plate and the guiding face of the chain guide may be greater than or equal to c while in contact with the chain guide. Thus, even after abrasion of the chain guide contact face of the guide link and the guiding face of the chain guide are taken into consideration, only the chain guide contact face of the guide link may be brought into contact with the guiding face of the chain guide over even longer driving times. As a result, abrasion of the guiding face can be further reduced.

Brief Description of the Drawings

Figure 1a is an expanded front view of a link

plate of the silent chain in accordance with an aspect of the present invention, and 1b is an expanded front view of a guide link.

Figure 2 is a diagram illustrating a positional relationship between the silent chain and the chain guide while contact is made with the chain guide.

Figure 3 is a diagram illustrating a positional relationship between the link plate and the guide link while contact is made with the chain guide.

Figure 4 is a diagram illustrating a preferred positional relationship between the link plate and the guide link while contact is made with the chain guide.

Figure 5 is an outlined plane diagram of a conventional silent chain.

Figure 6 is a schematic plan view of a conventional silent chain.

Figure 7a is an expanded front view of a conventional link plate, and 7b is an expanded front view of a conventional guide link.

Figure 8 is a diagram illustrating a problem with the conventional silent chain.

Figure 9 is a diagram illustrating a positional relationship with a chain guide when a conventional silent chain makes contact with the chain guide.

Figure 10 is a rear wheel-driving silent chain in accordance with an aspect of the present invention; wherein 10a is an expanded front view of a link plate, and 10b is an expanded front view of a guide link.

Figure 11 is a diagram illustrating a positional relationship between a rear wheel-driving silent chain and a chain guide while in contact with the chain guide.

Figure 12 is a schematic plan view of a rear wheel-driving silent chain.

Figure 13 is a schematic front view of a rear wheel-driving silent chain.

Figure 14a is an expanded front view of a conventional link plate, and 14b is an expanded front view of a conventional guide link.

Figure 15 is a diagram of a conventional rear wheel-driving silent chain illustrating its positional relationship to a chain guide while in contact with the chain guide.

Detailed Description of Preferred Embodiments

Figures 1-4 are diagrams explaining the silent chain according to an aspect of the present invention. The expanded front view of the link plate of the silent chain is illustrated in Figure 1a while Figure 1b is an expanded front view of the guide link of the silent chain, Figure 2 is a diagram illustrating the positional relationship between the silent chain and the chain guide while contact is made with the chain guide, and Figures 3 and 4 are diagrams illustrating the positional relationship between the link plate and the guide link while contact is made with the chain guide. Furthermore, since the overall configuration of the rear-driven silent chain is almost identical to the silent chain explained in Figures 5 and 6, detailed explanation for these will be omitted.

As is illustrated in Figure 1a, link plate 2 that is a constituent of the silent chain according to the present embodiment has a pair of tooth parts 21 projecting downward and a pair of pin holes 22 respectively provided on either side for inserting linking pins.

Then, when the pin hole diameter of link plate 2 is denoted as $\phi D1$, and the pin diameter is denoted as ϕd, a relationship expressed as $\phi D1 > \phi d$ is established in order to allow link plate 2 to rotate around the linking pin. In addition, as illustrated in Figure 1b, when the pin hole diameter of guide link 4 is denoted as ϕDg, because

the end of the linking pin needs to be press-fit into pin hole 41 of guide link 4, a relationship expressed as $\phi Dg > \phi d$ is established.

Furthermore, when the distance from pin hole centerline Ll of link plate 2 to the rear surface or chain guide contact surface 23 is denoted as hl, and the distance from pin hole centerline Lg of guide link 4 to the rear surface or chain guide contact surface 43 of guide link 4 is denoted as hg, a relationship expressed as hl > hg is established.

In such a case, clearance e' illustrated in Figure 9 is small, and the chain guide contact surface of the link plate is placed closer to the guiding surface of the chain guide. Accordingly, intensive contact between the guide links alone and the guiding surface of the chain guide can be limited. As a result, abrasion of the guiding surface of the chain guide can be reduced.

In addition, as is illustrated in Figure 2, clearance e is created between surfaces 43 of guide links 4 and guiding surface 51 of chain guide 5 when rear surfaces 23 of respective link plates 2 are brought into contact with guiding surface 51 of chain guide 5 as the silent chain makes contact with chain guide 5. The clearance e can be expressed as $e = hl - hg - c/2$. Here, c indicates the clearance between pin hole 22 of link plate 2 and the linking pin.

In such a case, rear surfaces 23 of link plates 2 can be reliably brought into contact with guiding surface 51 of chain guide 5 during operation of the silent chain. Accordingly, the contact surface pressure against guiding surface 51 is reduced, so that abrasion of guiding surface 51 can be reduced.

Furthermore, when deciding the size of clearance e, it is desirable to take into consideration the point that a condition in which shoulder parts 44 of the guiding

surface of guide link 4 protrude beyond shoulder parts 24 of link plates on the guiding surface side (Figure 3) does not occur when the silent chain makes contact with the chain guide. That is, it is preferable that shoulder parts 44 of guide link 4 be in the same plane as shoulder parts 24 of link plate 2, or that shoulder parts 44 be placed inside shoulder parts 24, as is illustrated in Figure 4.

In such a case, shoulder parts 44 of guide link 4 can be prevented from coming into contact with guiding surface 51 when contact is made with guiding surface 51 of chain guide 5. Accordingly, abrasion of guiding surface 51 caused by contact with shoulder parts 44 of guide link 4 can be prevented.

In an aspect of the invention, the clearance e, created between rear surface 43 of guide link 4 and guiding surface 51 of chain guide 5, may be zero. In such a case, a relationship expressed as hl - hg = c/2 is established.

According to another aspect of the invention, in the case of a chain with 6.35 mm pitch, the value of the hl - hg is approximately 0.2 mm, and it is preferable that it be greater than 0.2 mm in the case of a chain with a pitch greater than 6.35 mm.

In such a case, while contact is made with chain guide 5, not only rear surfaces 23 of link plate 2 but also rear surfaces 43 of guide link 4 make contact with guiding surface 51, so that the contact surface pressure against guiding surface 51 can be reduced, and abrasion of guiding surface 51 can be further reduced.

Furthermore, in this case, too, as described above, it is desirable that shoulder parts 44 of guide link 4 on the guiding surface's side do not protrude beyond shoulder parts 24 of link plate 2 on the guiding surface's side.

In another aspect of the invention, cases in which the relationship expressed as $hl-hg \leq c/2$ is

established have been explained. In actuality, while it is preferable that such a relational formula be satisfied by hl and hg, abrasion of guiding surface 51 can be reduced to some extent even when $0 < hl - hg < c/2$.

That is, in this case, only guide links 4 are prevented from making intensive contact with guiding surface 51 of chain guide 5. Accordingly, abrasion of guiding surface 51 of chain guide 5 can be reduced.

According to another aspect of the invention, a popular conventional guide link in the shape of a quasi-trapezoid may also be utilized. In addition, a rear-driven link plate having a pair of tooth parts on either side of the pin hole centerline may also be utilized for the link plate.

As has been described above, with the silent chain of the invention according to an aspect of the invention, when the distance from the pin hole centerline of the link plate to the surface facing the chain guide is denoted as hl, and the distance from the pin hole centerline of the guide link to the surface facing the chain guide is denoted as hg, a relationship expressed as $hl > hg$ is established. Therefore, intensive contact between the guide links alone and the guiding surface of the chain guide can be limited. Accordingly, the invention provides an effect of reducing abrasion of the guiding surface of the chain guide.

In addition, with the silent chain of the invention according to another aspect of the invention, when the clearance between the pin hole of the link plate and the linking pin is denoted as c, a relationship expressed as $hl \geq hg + c/2$ is established. In such a case, when contact is made with the chain guide, the chain guide contact surface of the link plate can be reliably brought into contact with the guiding surface of the chain guide. Accordingly, the invention provides an effect of reducing

contact surface pressure against the guiding surface, so that abrasion of the guiding surface can be further reduced.

Another aspect of the invention is explained and illustrated in Figures 10-15, wherein like reference numerals indicate generally similar elements as in the previous aspects of the invention.

Figures 10 and 11 are diagrams for explaining a rear wheel-driving silent chain in accordance with an aspect of the present invention. Figure 10a is an expanded front view of the link plate of the silent chain, Figure 10b is an expanded front view of the guide link of the silent chain, and Figure 9 is a diagram illustrating the positional relationship between the silent chain and the chain guide while in contact with the chain guide. Furthermore, since the overall configuration of the rear wheel-driving silent chain is almost identical to the rear wheel-driving silent chain explained in Figures 12 and 13, a detailed explanation will be omitted here.

As illustrated in Figure 10a, link plate 2 constituting the rear wheel-driving silent chain in accordance with the present embodiment has a pair of pinholes 21 provided on either side for linking pins and a pair of teeth 22 each provided on either side of pinhole center line Ll.

Then, if the pinhole diameter of link plate 2 is denoted as ϕDl, if the pinhole diameter of the linking pins is denoted as ϕd, the relationship ϕDl > ϕd is established, which allows link plate 2 to rotate around the linking pin. In addition, as illustrated in Figure 10b, if the pinhole diameter of guide link 4 is denoted as ϕDg, because the end of the linking pin must be press-fit into pinhole 41 of guide link 4, the relationship ϕDg < ϕd is established.

Furthermore, if the distance from pinhole center line Ll of link plate 2 to chain guide contact face 23 is denoted as hl, and if the distance from pinhole center line Lg of guide link 4 to chain guide contact face 43 of guide link 4 is denoted as hg, the relationship hg > hl is established. Furthermore, in this case, chain guide contact faces 23 and 43 are provided respectively on either side of pinhole center lines Ll and Lg of link plate 2 and guide link 4.

When the silent chain configured by combining such link plates 2 and guide links 4 contacts the chain guide, as illustrated in Figure 11, the clearance between chain guide contact face 23 of link plate 2 and guiding face 51 of chain guide 5 is greater than c/2 (provided that $c = \phi Dl - \phi d$). As a result, only chain guide contact face 43 of guide link 4 contacts guiding face 51 of chain guide 5 over a long driving time, so that the contact face pressure of chain guide 5 acting guiding face 51 can be reduced, and abrasion of guiding face 51 can be reduced.

In contrast, when the conventional rear wheel-driving silent chain contacts chain guide 5, the clearance between the chain guide contact face of the link plate and the guiding face of the chain guide is merely c/2. Thus, if the total amount of abrasion of the chain guide contact face of the guide link and the guiding face of the chain guide exceeds c/2, the chain guide contact face of the link plate contacts the guiding face of the chain guide, so that the contact pressure to the guiding face increases, and wear is generated on the guiding face.

Although a case in which hg > hl was explained in the aforementioned aspect of the invention, the relationship $hg \geq hl + c/2$ may also be established. In this case, the clearance between chain guide contact face 23 of link plate 2 and guiding face 51 of chain guide 5 is greater than or equal to c while in contact with the chain

guide. As a result, only chain guide contact face 43 of guide link 4 can be brought into contact with guiding face 51 of chain guide 5 over even longer driving times. Thus, abrasion of guiding face 51 can be further reduced.

As described above, with the rear wheel-driving silent chain pertaining to an aspect of the invention, if the distance from the pinhole center line of the link plate to the surface facing the chain guide is denoted as hl, and if the distance from the pinhole center line of the guide link to the surface facing the chain guide is denoted as hg, the relationship hg > hl is established. Thus, the clearance between the chain guide contact face of the link plate and the guiding face of the chain guide can be increased while in contact with the chain guide. As a result, only the chain guide contact face of the guide link can be brought into contact with the guiding face of the chain guide over a long driving time. In this manner, contact pressure on the guiding face can be reduced, resulting in the effect that abrasion of the guiding face can be reduced.

In addition, with the rear wheel-driving silent chain pertaining to another aspect of the invention, if the clearance between the pinhole of the link plate and the linking pin is denoted as c, the relationship $hg \geq hl + c/2$ is established. In this case, the clearance between the chain guide contact face of the link plate and the guiding face of the chain guide is greater than or equal to c. Thus, even after abrasion of the chain guide contact face of the guide link and the guiding face of the chain guide are taken into consideration, only the chain guide contact face of the guide link can be brought into contact with the guiding face of the chain guide over even longer driving times, resulting in the effect that abrasion of the guiding face can be further reduced.